## SHRIMP BIOLOGY PROGRAM

This year we began investigating factors that we consider essential to the commercial culture of shrimp. A prototype hatchery was established with one 1,700-liter (450-gallon) and four 940-liter (250-gallon) tanks. In the first experiment with this equipment, 220,000 brown shrimp were reared to postlarvae. One of the highlights of the year was the shipment of 80,000 of these postlarvae to the Louisiana Wild Life and Fisheries Commission Laboratory at Grande Terre, La., where they were stocked in ponds. Also, for the third straight year we were able to grow shrimp rapidly in ponds that had been fertilized, but to which no supplemental food was added.

Two major problems still remain. The first is to develop an artificial food that will support rapid growth of dense populations of subadult and adult shrimp in ponds. The second is to induce adult shrimp to develop to sexual maturity and reproduce in captivity. Once this has been accomplished we will try to develop techniques for regulating sexual development so that the time of spawning can be controlled. We already have made some progress on the development of a suitable food, but during the coming year, the major effort of the Food and Artificial Environment Project and the Adult and Juvenile Culture Project will be directed specifically toward this objective.

Personnel in the Florida Bay Ecology Studies Project completed an extensive ecological survey of Florida Bay and the Florida Keys.

Harry L. Cook, Acting Program Leader

### Larval Culture

Hatchery facilities for rearing larval shrimp were modified the past year, and four 940-liter (250-gallon) tanks were added as rearing containers. In our first experiment with the new tanks and the 1,700-liter (450-gallon) tank, an estimated 220,000 brown shrimp were reared to postlarvae. The hatch was poor--we think because of the low salinity of 27 p.p.t. (parts per thousand). Of these larvae that did hatch, survival from first nauplius to first postlarva was 70 to 88 percent. The largest number of postlarvae reared in one 940-liter tank was 61,000. We established that it was not necessary to change the water during the culture or to filter the water when the larvae were in the mysis stage.

We shipped about 80,000 postlarvae to Louisiana where they were placed in ponds at the State of Louisiana research facility at Grande Terre Island. For shipment, postlarvae were placed in water in plastic bags; the bags were then filled with oxygen, sealed, and placed in styrofoam boxes. These boxes (5,000 to 10,000 postlarvae per box) were then sealed. The Louisiana Wild Life and Fisheries Commission flew the postlarvae to Louisiana in one of their planes, and although the postlarvae were boxed for about 6 hours, mortality was less than 1 percent.

We completed an experiment to determine the effects of different temperatures on survival of brown shrimp larvae. Four temperatures were tested at a salinity of 30 p.p.t. The tolerance of the larvae appeared to vary considerably between stages; nauplii survived best at 24° C. (75.2° F.), and as the shrimp became older, i.e., protozoeae and myses, survival usually increased with an increase in temperature (table 2).

We completed two feeding experiments with brown shrimp larvae this spring. In one, protozoeae were fed four kinds of algae as well as a mixture of the four types. Algae used were *Cyclotella nana*, *Isochrysis galbana*, *Skeletonema costatum*, and *Thalassiosira* sp. *Skeletonema* was fed at rates of 500, 1,000, and 1,500 cells per milliliter, and numbers of the other algae used were adjusted to concentrations that gave cell volumes equal to those of the *Skeletonema*. Even the highest concentrations of algae apparently were too low, and all larvae died. We were, however, able to draw some tentative conclusions as to the relative value of the different algae from the lengths of time the larvae survived and the stage of development attained (table 3). *Isochrysis galbana* was the poorest food; the mixed algae and *Thalassiosira* were best.

In a second feeding experiment, first myses were fed newly hatched *Artemia* nauplii. Those fed at a rate of three nauplii per milliliter of water had an 82-percent survival and consumed an average of 18 *Artemia* per day. Those fed at the rate of five *Artemia* per milliliter of water had only 65-percent survival but consumed about 70 percent more *Artemia*. The groups took the same time to reach the first postlarval stage.

We also cultured stone crabs (*Menippe mercenaria*) from eggs deposited in a 378-liter (100-gallon) tank. On the first day after hatching, the larvae did not appear to feed on *Artemia* nauplii, so we fed them algae. By the

Table 2.--Percentage survival of brown shrimp larvae at selected temperatures

| Temperature | | Nauplius I to protozoea I | Protozoea I to mysis I | Mysis I to postlarva I |
|---|---|---|---|---|
| °F. | °C. | Percent | Percent | Percent |
| 68.0 | 20.0 | 7 | 0 | 88 |
| 75.2 | 24.0 | 84 | 63 | 93 |
| 82.4 | 28.0 | 44 | 73 | 94 |
| 89.6 | 32.0 | 28 | 68 | 98 |

Table 3.--Survival and stage of development attained by brown shrimp protozoeae fed selected algae

| Algae fed | Survival time | Stage of development attained 1/ |
|---|---|---|
| | Days | |
| Isochrysis galbana | 2 | PI |
| Cyclotella nana | 3 | PI |
| Skeletonema costatum | 4 | PI |
| Mixture | 4 | PII |
| Thalassiosira sp. | 5 | PII |

1/ PI is first-stage protozoeae.
PII is second-stage protozoeae.

second day, however, they appeared stronger, and brine shrimp nauplii were added. Both foods were fed throughout the remainder of the larval stages. Temperature ranged from 23° C. (73° F.) to 24° C. (75° F.), and salinity from 20.5 to 18.4 p.p.t.

The survival of the crabs in the zoeal stages was high but decreased during the megalops stage because of cannibalism. When the megalops were placed in a tank with an abundant growth of attached algae, they hid in the algae, thus reducing mortality. The young crabs would not feed on fish meal but would eat shredded fresh shrimp. The larval stage lasted about 1 month, and at the end of 2 months we had an undetermined number of crabs whose size ranged up to 10 mm. (0.5 inch) carapace width.

A small greenhouse built for the mass culturing of algae used to feed larval shrimp enabled us to begin research to find a satisfactory enrichment for growing algae in large cultures in natural sea water. We are currently investigating three methods of mass culture: (1) inducing blooms of naturally occurring phytoplankton in sea water that has been screened, but not filtered; (2) inoculating filtered and enriched sea water with several diatoms that have differing physiological requirements; and (3) making assays with several diatoms and various combinations of additives before we inoculate the large tanks.

Because of past difficulties in culturing algae in enriched sea water, we completed a series of experiments to determine if a medium made with artificial sea salts could be used. Instant Ocean[1] sea water supported growth of Skeletonema when supplemented with Tris buffer, potassium nitrate, sodium phosphate, and iron. Growth of Cyclotella required a vitamin mixture as well as the other additives.

Harry L. Cook, Project Leader

## Culture of Juvenile and Adult Shrimp

Experimental rearing of penaeid shrimp in two 0.05-hectare (1/8-acre), brackish-water ponds continued this year. We distributed rice husks in one pond to increase the surface area of the bottom (thus encouraging growth of micro-organisms) and to fertilize the pond's water inexpensively. The second pond was untreated. We put about 9,000 brown shrimp postlarvae in each pond, which then had one shrimp per 0.05 $m.^2$ (0.5 $ft.^2$) of bottom. These postlarvae were reared from eggs spawned in the laboratory.

As in previous years, initially rapid shrimp growth in both ponds was followed by a period of slow growth (tables 4 and 5). Toward the end of the study, shrimp in both ponds were fed a commercially prepared rabbit "chow" at the rate of 5 percent of their body weight per day. This addition of food increased the average daily rate of growth.

Table 4.--Lengths and numbers per pound (whole shrimp) of brown shrimp held in an untreated, brackish-water pond, 1967

| Date | Length | | | | Whole shrimp per pound |
|---|---|---|---|---|---|
| | Average | | Daily increment during period | | |
| | Mm. | Inches | Mm. | Inches | Number |
| Apr. 28 | 6.5 | 0.26 | -- | -- | 567,500 |
| May 18 | 29.3 | 1.15 | 1.14 | 0.044 | 1,892 |
| June 15 | 79.9 | 3.14 | 1.81 | 0.071 | 114 |
| July 13 | 87.0 | 3.42 | 0.25 | 0.009 | 91 |
| Aug. 17 1/ | 80.8 | 3.18 | -0.18 | -0.007 | 116 |
| Sept. 19 | 88.6 | 3.48 | 0.24 | 0.009 | 86 |

1/ Feeding began Aug. 31.

Table 5.--Lengths and numbers per pound (whole shrimp) of brown shrimp held in a fertilized, brackish-water pond, 1967

| Date | Length | | | | Whole shrimp per pound |
|---|---|---|---|---|---|
| | Average | | Daily increment during period | | |
| | Mm. | Inches | Mm. | Inches | Number |
| Apr. 28 | 6.5 | 0.26 | -- | -- | 567,500 |
| May 18 | 26.0 | 1.02 | 0.98 | 0.038 | 2,838 |
| June 15 | 75.7 | 2.98 | 1.78 | 0.070 | 126 |
| July 13 | 86.1 | 3.39 | 0.37 | 0.014 | 93 |
| Aug. 17 1/ | 91.8 | 3.61 | 0.16 | 0.006 | 74 |
| Sept. 19 | 103.7 | 4.08 | 0.36 | 0.014 | 49 |

1/ Feeding began Aug. 4.

[1] Trade names referred to in this publication do not imply endorsement of commercial products.